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A rapid assessment of the invasive status of *Eucalyptus* species in two South African provinces

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Gum trees, or eucalypts (*Eucalyptus* species), have been targeted for invasive alien plant clearing programmes in many parts of South Africa. This has caused some dissatisfaction where the species concerned also have useful characteristics, and stakeholders contend that some of these useful species are not invasive. A rapid assessment of the invasive status of *Eucalyptus* species at 82 sites in South Africa (54 in the Western Cape and 28 in Mpumalanga) indicated that only Red River gum (*E. camaldulensis*) and flooded gum (*E. grandis*) are clearly invasive. Surveys were not undertaken in parts of the Western Cape known to be invaded by spider gum (*E. lehmannii*); the invasive status of this species is well known and is not contested. Red River gum has transformed long stretches of rivers and its importance as a major weed has been underestimated in previous reviews of alien plant invasions in South Africa. Most other species were naturalized. We recommend that projects aimed at clearing eucalypts should focus on riparian areas and nature reserves (where all eucalypts have deleterious effects), but that clearing projects outside these areas should only target species known to be invasive until such time as the invasive status of the other eucalypts (notably sugar gum, *E. cladocalyx*, and karri, *E. diversicolor*) can be ascertained with a greater degree of confidence.

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Introduction

Gum trees, or eucalypts, in the genus *Eucalyptus* number approximately 400 species, almost all of them endemic to Australia.[1] In their native range they occupy a wide variety of habitats and bioclimates. Eucalypts have been very widely planted worldwide.[2] By 1940, approximately 149 *Eucalyptus* species had been established in South Africa. Early introductions took place mainly through the colonial forest administration of the Cape Colony in the late 19th century.[3] In South Africa, eucalypts are now used for timber, poles, firewood, as shelterbelts and ornamentals, and are valuable sources of nectar and pollen necessary for the production of honey.[4,17]

Although eucalypts deliver many benefits to South African society, they also have undesirable influences. Eucalypt plantations use large amounts of water — for example, the afforestation of catchments in Mpumalanga province with eucalypts resulted in the total drying-up of streams 6–12 years after planting.[5] In addition, some eucalypts are considered invasive with potentially negative effects on natural habitats.[6,7]

In terms of the regulations under the Conservation of Agricultural Resources Act (Act No. 43 of 1983), landowners in South Africa are legally responsible for the control of invasive alien plants (including seven species of eucalypts) on their properties. These regulations define three categories of declared weeds and invaders. Category 1 refers to prohibited weeds that must be controlled in all situations. Category 2 includes plants with commercial value that may be planted in demarcated areas subject to a permit, provided that steps are taken to control spread, and planting is prohibited in riparian areas and wetlands. Category 3 includes ornamental plants that may no longer be planted or traded. Specimens may remain in place provided a permit is obtained and steps taken to control their spread.

Recently, concern was raised by beekeepers that extensive clearing of eucalypts would result in a significant reduction in pollen and nectar resources on which the apiculture industry depended. It was argued that this could also have potentially serious consequences for the deciduous fruit industry due to the

Table 1. Invasive status of *Eucalyptus* species observed that are listed in the regulations of the Conservation of Agricultural Resources Act (Act No. 43 of 1983). The status of species as aliens was classified following definitions provided by Richardson *et al.*[8] (see text). Karri (*E. diversicolor*) is also listed in the regulations but was not observed during the survey.

Species	Province	Habitat	Number of observations	Establishment	Invasive category
Red River gum (*E. camaldulensis*)	Western Cape	Riverine	8	Self-sown	Naturalized
		Riverine	14	Self-sown	Invasive
		Riverine	7	Self-sown	Transformer
		Dam shore	1	Self-sown	Invasive
		Open slope	1	Planted	Naturalized
		Plantation	2	Planted in woodlot	Naturalized
		Plantation	1	Planted in woodlot	Invasive
		Roadside	1	Planted as ornamental	Naturalized
	Mpumalanga	Riverine	4	Self-sown	Naturalized
		Riverine	4	Self-sown	Invasive
		Riverine	1	Self-sown	Transformer
		Plantation	3	Planted in woodlot	Naturalized
		Plantation	2	Planted in woodlot	Invasive
Sugar gum (*E. cladocalyx*)	Western Cape	Plantation	10	Planted in woodlot	Naturalized
		Edge of field	3	Shelterbelt	Naturalized
		Roadside	2	Ornament	Naturalized
		Pine plantation	1	Planted as firebreak	Invasive
Flooded gum (*E. grandis*)	Mpumalanga	Riverine	1	Self-sown	Naturalized
		Riverine	7	Self-sown	Invasive
		Plantation	2	Planted in woodlot	Naturalized
		Plantation	4	Planted in woodlot	Naturalized
Spider gum (*E. lehmannii*)	Western Cape	Plantation	1	Planted in woodlot	Naturalized
Grey ironbark (*E. paniculata*)	Mpumalanga	Plantation	1	Planted	Naturalized
Black ironbark (*E. sideroxylon*)	Western Cape	Roadside	1	Planted as ornamental	Naturalized

reduced availability of pollinators. The rationale for clearing several eucalypt species, including amenity trees (many of which are not listed in the regulations), as part of regional Working for Water projects, has also been questioned by various interest groups. Such concerns potentially undermine the public support of the Working for Water initiative.

This paper reports on the results of a rapid survey, funded by the Working for Water programme, that aimed to assess the invasive status of the *Eucalyptus* species listed in the above regulations.

A rapid survey of eucalypts in two provinces

Rapid assessments of the invasiveness of eucalypts in the Western Cape and on the Mpumalanga escarpment were undertaken during late 2002 and early 2003. These took the form of spot surveys along stretches of the Sonderend, Berg and Olifants rivers in the Western Cape and in the catchments of the Sabie and Crocodile rivers in Mpumalanga. At each site, we noted any species regenerating naturally, the most likely method of establishment, the habitat, and we classified the population in terms of the relevant invasive category (naturalized or invasive). 'Naturalized' populations showed evidence of consistent reproduction, often recruiting offspring freely, usually close to adult plants (but not necessarily invading natural, semi-natural or man-made ecosystems). Species were classified as 'invasive' at a site if they produced reproductive offspring, often in very large numbers, more than 100 m from parent plants.[8,9]

Spider gum (*E. lehmannii*) is widely acknowledged as a major invasive species in the Western Cape.[10,11] We did not survey areas known to be invaded by this species only (notably the Agulhas Plain and the Cape Peninsula), as the status of this species as an invader was not contested.

Invasions by eucalypts and habitats invaded

Our survey covered 82 sites, 54 in the Western Cape and 28 in Mpumalanga. Of the species listed in regulations as invasive, we encountered only single specimens of black ironbark (*E. sideroxylon*), grey ironbark (*E. paniculata*) and spider gum (*E. lehmannii*). No karri (*E. diversicolor*) was observed. All the eucalypts encountered were 'naturalized',[8] but only Red River gum (*E. camaldulensis*) and flooded gum (*E. grandis*) were clearly 'invasive'[8] (Table 1).

Red River gum was found to be highly invasive along river courses in both the Western Cape (46% of observations classified as invasive) and in Mpumalanga (28% of observations classified as invasive). In the middle reaches of the Berg River and the lower reaches of the Sonderend River, this species now dominates the riverine vegetation and is clearly in the 'transformer' category.

Flooded gum invades river courses in Mpumalanga, where it was classified as invasive at 50% of our sites. This species was not recorded in the Western Cape survey. Spider gum, although not assessed in this survey, is known to invade fynbos vegetation on the Agulhas Plain and the Cape Peninsula. Sugar gum (*E. cladocalyx*) was found to be invasive in a pine plantation in the Western Cape, but was not found to be invading surrounding natural vegetation.

Discussion

Eucalypts feature on many national and regional weed lists. *The Global Compendium of Weeds*[12] lists 67 eucalypts that various sources have categorized as 'weed', 'sleeper weed', 'naturalized', 'garden escape' or 'casual alien'. Such lists suggest that eucalypts have been fairly successful as invaders. They have, however, been markedly less successful as invaders than several other tree genera (for example, pine trees in the genus *Pinus*) that have enjoyed similar levels of dissemination as aliens. Given the history of widespread planting of eucalypts, and the many species involved, we would expect to observe the full range of outcomes in terms of success as aliens. However, in most parts of the world where eucalypts have invaded, they seldom spread considerable distances from planting sites, and their regeneration is frequently sporadic. Their mediocre performance as invaders worldwide is puzzling.[13]

Our survey was rapid and was based on visual observation. Nevertheless, the survey highlighted the widespread occurrence of two eucalypts, Red River gum and flooded gum, as invaders. Red River gum is the greatest threat as it is found throughout much of South Africa and has already transformed long stretches of rivers and dam shores. Red River gum is a major environmental weed. Although highly ranked in a detailed survey of riparian invaders in the Western Cape,[18] its importance is not accurately reflected in recent reviews of the invasive alien flora of southern Africa. For example, this species is not included in a list of the 84 most important environmental weeds in southern Africa[14] nor in a list of 61 species ranked according to 17 criteria affecting their importance as invasive alien plants in South Africa.[15]

Richardson *et al.* [8] provided a five-stage invasion model showing the sequence of events from introduction to invasion. Limiting factors that restrict the spread of introduced species in regions are referred to as barriers to invasion. The plant must first overcome major geographic barriers to arrive in a new locality. It must then be able to survive in its new environment. Next, it has to be able to reproduce unaided in the new environment. Then, the plant must be able to disperse some distance from its parent and establish itself, initially in disturbed, but eventually in undisturbed environments. Evidence from this and other studies show that Red River gum, flooded gum and spider gum have crossed these final barriers. Our findings concur with Henderson,[6] who classifies these three species as habitat transformers.

Observations received after our survey was completed suggest that sugar gum is more invasive under certain conditions than our results show. At a site in the Viljoen's Pass near Grabouw (34°06′40″S, 19°03′27″E), sugar gum seedling recruitment took place after a veldfire in the mid-1980s (J. Syphus, pers. comm.). Also, one of us (G.G.F.) observed seedling recruitment of sugar gum near Ladismith (33°27′49″S, 21°16′17″E) after a recent fire had burned through a mature stand of trees. Lastly, a recent study recorded that sugar gum, introduced as an ornamental to Western Australia from South Australia, spread up to 70 m away from plantings. This recruitment was also associated with the occurrence of fires.[16]

Recommendations

This survey has raised a number of questions about the true invasive status of eucalypts in South Africa. While many species have been here for over 100 years, only a few have become truly invasive. Detailed investigations are warranted to establish the true invasive status of eucalypts in South Africa. Sugar gum needs to be explored in detail as: (a) there is some evidence to suggest that it could become invasive, especially where it is subjected to periodic fires, (b) there is often a long time lag between the planting of a species and when it becomes invasive, and (c) as it is widely planted there are many localities from where it can potentially invade.

As far as the management of eucalypts as invasive alien species is concerned, we recommend that clearing projects should focus on removing these trees from riparian areas (where water use is likely to be excessive) and nature reserves (where all eucalypts have undesirable effects on biodiversity), but that clearing projects outside of these areas should focus only on Red River gum, flooded gum and spider gum.

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